ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA
DEPARTMENT OF
MECHANICAL ENGINEERING

SECOND SEMESTER EXAMINATIONS

2017/2018 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE: MEE 506– Applied Thermodynamics II (3 Units)

CLASS: 500 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer any **FOUR** questions

Date: July/August, 2018

Question 1

a) Briefly answer the following questions:

i. What do you mean by compressor?

ii. Why is the clearance volume provided in a reciprocating compressor?

b) A single-stage, single-acting reciprocating compressor has a bore of 210 *mm* and a stroke of 320 *mm*. It runs at a speed of 550 *rpm*. The clearance volume is 5 % of the swept volume and the polytropic index is 1.35 throughput. Intake pressure and temperature are 99 kN/m^2 and 20 ^0C, respectively, and the compression pressure is 570 kN/m^2. Determine,

i. the Free Air Delivered (FAD) in m^3/min (free air conditions 101.325 kN/m^2 and 15 ^0C)

ii. the volumetric efficiency referred to the free air conditions

iii. the air delivery temperature

iv. the cycle power

v. the isothermal efficiency, neglecting clearance

Question 2

a) Briefly answer the following questions:

i. Mention four (4) usage of compressed air?

ii. What is the use of inter-cooler in a 2-stage air compressor?

b) A four-stage, single-acting reciprocating compressor running in an atmosphere at pressure and temperature of 1.013 *bar* and 15 ^0C, respectively, has a free air delivery at 2.8 m^3/min. The suction pressure and temperature are 0.95 *bar* and 30 ^0C respectively. Calculate the indicated power

required, assuming complete inter-cooling, n=1.35, and that the machine is designed for minimum work. The delivery pressure is to be 85 *bar*.

c) A single-stage, double-acting air compressor has Free Air Delivery (FAD) of 13.5 m^3/min measured at 1.013 *bar* and 15 ^0C. The pressure and temperature in the cylinder during induction are 0.95 *bar* and 30 ^0C respectively. The delivery pressure is 6.5 *bar* and the index of compression and expansion, n=1.35. Calculate:

i. the indicated power required

ii. the volumetric efficiency. The clearance volume is 5 % of the swept volume

Question 3

a) Briefly answer the following questions:

i. List four (4) classifications of boilers.

ii. Give four (4) applications of boilers.

b) A coal fired boiler installation is seen to have operating parameters as given in Table 1.

Table 1: Operating parameters of a coal fired boiler

S/N	Operating Parameter		Value	Unit
	Symbol	Description		
1.	m_f	Mass of fuel per kg of fuel	1.00	$kg/kg\ of\ coal$
2.	m_{steam}	Mass of steam generated per kg of fuel	3.91	$kg/kg\ of\ coal$
3.	m_{dfg}	Mass of dry flue gas per kg of fuel	7.54	$kg/kg\ of\ coal$
4.	f_{co}	Percentage by volume of CO present in flue gases	0.55	%
5.	f_{co_2}	Percentage by volume of CO_2 present in flue gases	14.00	%
6.	f_c	Fraction of carbon present per kg of fuel	0.4165	
7.	T_a	Temperature of air entering combustion chamber	31	^0C
8.	T_g	Temperature of flue gases	190	^0C
9.	c_{p_g}	Specific heat of dry flue gases	0.23	$kcal/kg$
10.	$c_{v_{coal}}$	Calorific value of fuel	3501	$kcal/kg$
11.	$\Delta h = h - h_w$	Difference between enthalpy of final steam produced and enthalpy of feed water	636.87	$kcal/kg$
12.	Q_{carbon}	Heat loss due to incomplete combustion of one kg of carbon	5744	$kcal/kg$

Determine,

i. Total heat available due to fuel burning.

ii. Heat used for generation of steam.

iii. Heat lost due to incomplete combustion.

iv. Heat loss to dry flue gases.

v. Other heat losses.

Question 4

a) Briefly answer the following questions:

i. What is the main application of steam nozzle in steam turbine?

ii. State two contributions to frictional losses in nozzles.

b) In a nozzle, steam expands from 12 *bar* and 300 ^0C to 6 *bar* with flow rate of 5 *kg/s*. Determine,

i. throat and exit area if exit velocity is 500 *m/s* and velocity at inlet to nozzle is negligible.

ii. Also find coefficient of velocity at exit.

Note: Coefficient of velocity is the ratio of actual velocity of fluid at nozzle exit to the velocity at exit considering isentropic flow through nozzle.

Question 5

a) Briefly answer the following questions:

i. List four (4) classifications of steam engine.

ii. Draw and label a schematic illustration of a simple steam engine plant?

b) A double acting steam engine has bore of 32 *cm* and stroke to bore ratio of 2.1 with cut-off occurring at 42 % of stroke. Steam enters the engine cylinder at 8 *bar* and exhausts at 0.15 *bar*. Engine runs at 200 *rpm*. Neglecting clearance volume and considering diagram factor of 0.6 determine the indicated horse power.

c) In a single acting steam engine, steam is admitted at 15 *bar*, 200 ^0C and exhausts at 0.75 *bar* with cut-off occurring at 25 % of stroke. Engine produces 150 *hp* at 240 *rpm*. The mechanical efficiency of engine is 85 %, diagram factor is 0.7, brake thermal efficiency is 20 % and stroke to bore ratio is 1.5. Determine,

i. the cylinder dimensions, and

ii. the specific steam consumption.

Note: Neglect the cross-section area of piston rod and clearance volume.

Question 6

a) Briefly answer the following questions:

i. List four (4) classifications of steam turbine.

ii. State four (4) means energy is lost in steam turbines.

b) A steam engine operates with steam being supplied at 0.2 *MPa*, 250 ^0C and expanding up to 0.3 *bar*. Steam is finally released out at 0.05 *bar*. Determine,

i. Draw the modified Rankine cycle

ii. the modified Rankine cycle efficiency, and

iii. compare it with the efficiency of Carnot cycle operating between given limits of pressure.

Note: Neglect feed pump work.